# NATIONAL BUREAU OF STANDARDS REPORT

6403

## CAPACITY TESTS OF GENERAL ELECTRIC HEAT PUMP MODEL 21 WT33G1

by

J. C. Davis, W. M. Ellis and P. R. Achenbach

Report to

Housing Construction Division
Directorate of Installations
United States Air Force
Washington, D. C.

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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CAPACITY TESTS OF GENERAL ELECTRIC HEAT PUMP
MODEL 21 WT33G1

by

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Air Conditioning, Heating, and Refrigeration Section
Building Technology Division

to

Housing Construction Division
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## ABSTRACT

At the request of the Housing Construction Division, Directorate of Installations, United States Air Force, cooling and heating capacity tests were made of a General Electric Company heat pump, Model 21 WT33G1. The specimen was selected by Air Force representatives from among those furnished by the manufacturer for installation at Homestead Air Force Base, Florida. The indoor and outdoor conditions under which tests were to be made were agreed upon in a meeting of representatives of the U. S. Air Force, the General Electric Company, and the National Bureau of Standards. The tests, except for minor deviations, were made under the procedures and conditions specified in the American Society of Refrigerating Engineers Standard No. 16-56. The cooling capacity of the unit varied linearly from 35,400 Btu/hr to 31,100 Btu/hr for the range of outdoor temperature from 85°F to 105°F when the indoor conditions were maintained at 80°F dry bulb temperature and 67°F wet bulb temperature. Lowering the indoor dry bulb temperature to 75°F decreased the cooling capacity of the unit 2350 Btu/hr for the same range of outdoor temperatures. The heating capacity varied linearly from 38,400 Btu/hr to 24,600 Btu/hr for the range of outdoor temperature from 50°F to 20°F when the indoor dry bulb temperature was maintained at 70°F and the outdoor coil was kept free of frost. Under severe frosting conditions at an outdoor temperature of 35°F the average hourly heat output was reduced about 2900 Btu/hr or about 9.0 percent by the insulating effect of the frost on the outdoor coil and the interruption of heating during the defrosting period. The defrost cycle lasted from 3 to 4 1/2 minutes and was repeated every 35 or 40 minutes under the test conditions. The coefficient of performance varied linearly with outdoor temperature under both heating and cooling conditions. The coefficient of performance was 2.03 at an outdoor temperature of 35°F under heating conditions, and 1.75 at an outdoor temperature of 95°F under cooling conditions.

# 1. INTRODUCTION

In accordance with a request by letter of October 13, 1958, from Colonel Guy H. Goddard, Chief, Housing Construction Division, Directorate of Installations, Headquarters, United States Air Force, cooling and heating capacity tests were made of a General Electric heat pump, Model 21 WT33G1. The specimen tested was one of two chosen by Air Force representatives from units furnished for installation at the Homestead Air Force Base, Florida. Since the testing of this unit was not detailed in purchase specifications, the testing conditions were agreed upon in a meeting held on October 8, 1958, with the United States Air Force, the General Electric Company, and the National Bureau of Standards represented.

The following table summarizes the indoor and outdoor temperature and humidity conditions agreed upon for the tests. Carrying out the three cooling tests at an indoor temperature of 75°F was made contingent upon the cumulative cost of the tests. Actually, only two of these tests, at outdoor dry bulb temperatures of 105°F and 85°F, were performed. One heating test was to be made at an outdoor temperature of 35°F with some frost accumulation on the outdoor coil to determine the effect of the frost on the heating capacity and to permit an automatic defrosting cycle to occur during which the heating function would be interrupted. This test was to continue for at least 3 hours.

COOLING TESTS

| Indoor Conditions | | | Outdoor Temperature |
|---|---|---|---|
| DB (°F) | WB (°F) | R.H. (%) | DB (°F) |
| 80 | 67 | - | 85 |
| 80 | 67 | - | 95 |
| 80 | 67 | - | 105 |
| 78 | 65 | - | 91 |
| 75 | - | 50 | 85 |
| 75 | - | 50 | 95 |
| 75 | - | 50 | 105 |

HEATING TESTS

| Indoor Temp, DB (°F) | Outdoor Temp, DB (°F) | Special Conditions |
|---|---|---|
| 70 | 20 | Outdoor coil, frost-free |
| 70 | 35 | " " " " |
| 70 | 50 | " " " " |
| 70 | 35 | Outdoor coil, frosted |

One cooling test at an outdoor DB temperature of 95°F and indoor conditions of 80°F DB and 67°F WB was to be made with an external static resistance on the indoor blower of 0.30 in. W.G.; which was an intermediate value between that used by the General Electric Co. for testing and that anticipated in the Air Force houses. This test was then to be repeated with an external static resistance of 0.15 in. W.G. and all other cooling tests and the heating tests were to be made without further adjustment of the air dampers. The adjustments for static pressure were to be made with the compressor operating and the indoor coil condensing room moisture in the normal way. The heating tests were then to be performed without further adjustment of the air dampers. The air circulation rate of the indoor blower was not specified.

The vapor line and liquid line of the test unit were each to be approximately 25 ft long, with ten feet of the total being exposed to outdoor conditions.

The engineering data submitted to the U. S. Air Force by the General Electric Co. indicated that the capacity of the specimen would be as follows:

| Outdoor Temp. (°F) | Indoor Temp. (°F) | | Capacity, (Btu/hr) |
|---|---|---|---|
| | Cooling Conditions | | |
| DB | DB | WB | |
| 95 | 80 | 67 | 33,500 |
| | Heating Conditions | | |
| DB | DB | WB | |
| 20 | 70 | - | 24,500 |
| 35 | 70 | - | 32,000 |
| 50 | 70 | - | 37,800 |

## 2. DESCRIPTION OF TEST SPECIMEN

The General Electric 21 WT33G1 heat pump is known as a "split type" or "remote type" heat pump in which one section of the apparatus is placed outdoors and the other inside the home at a suitable place for delivering conditioned air. These two sections were designated respectively on nameplates as 21 WTA40B11 and 21 WTB32E9, and will be referred to hereafter in the report as the outdoor unit and the indoor unit.

During the cooling cycle, the coil of the indoor unit served as an evaporator, absorbing heat; and during the heating cycle, as a condenser, rejecting heat. This operational change was accomplished by means of a change in direction of circulation of the refrigerant through the system, using thermostatically-controlled solenoids in a four-way valve. During the tests the solenoids were controlled by a manually-operated switch to preclude automatic shifting from cooling to heating conditions and vice versa. Thermostatic expansion valves were used as the liquid refrigerant flow control devices in both the indoor and outdoor units with check valves to bypass each when not needed. Following the new ASRE refrigerant designations, the refrigerant used was R-22.

A schematic diagram of the heat pump system and auxiliary test instrumentation is shown in Figure 1. A list of line sizes between the indoor and outdoor units is shown below. The liquid and vapor lines were each about 25 ft in length.

During the tests the vapor line was insulated with a glass fiber type material 1 in. thickness, vapor sealed.

| | | |
|---|---|---|
| 1. | Liquid line except for flowmeter manifold*, in. | 3/8 OD |
| 2. | Lines in manifold*, in. | 1/2 OD |
| 3. | Vapor line, in. | 7/8 OD |

* Part of testing apparatus.

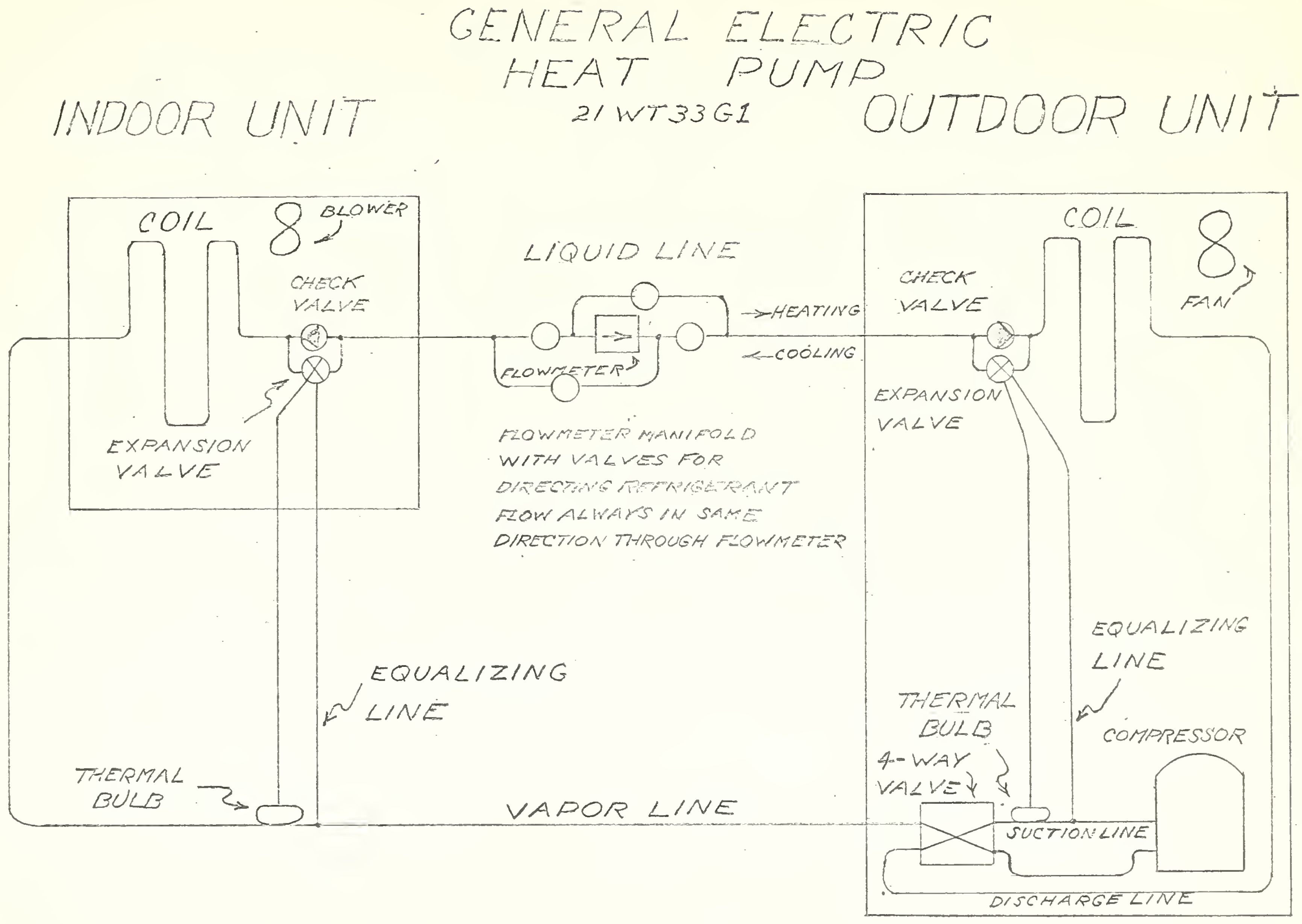
GENERAL ELECTRIC
HEAT PUMP
21 WT33G1
INDOOR UNIT
OUTDOOR UNIT
COIL
BLOWER
CHECK VALVE
EXPANSION VALVE
LIQUID LINE
FLOWMETER
→HEATING
←COOLING
FLOWMETER MANIFOLD
WITH VALVES FOR
DIRECTING REFRIGERANT
FLOW ALWAYS IN SAME
DIRECTION THROUGH FLOWMETER
CHECK VALVE
COIL
FAN
EXPANSION VALVE
EQUALIZING LINE
EQUALIZING LINE
THERMAL BULB
THERMAL BULB
4-WAY VALVE
COMPRESSOR
VAPOR LINE
SUCTION LINE
DISCHARGE LINE

FIG 1

## INDOOR UNIT

The indoor unit consisted essentially of a finned coil, a blower for circulating conditioned air through the duct system of the house, a motor for powering the blower, an expansion valve, a check valve, and a drain pan for collecting condensate. The indoor unit was designed for installation of resistance heaters to supplement compressor heating during extremes of cold weather. However, because of the mild weather usually prevailing at the Homestead Air Force Base, these heaters were not provided in these units. Material and dimensional data on the components of the indoor unit are contained in the Appendix at the end of the report.

Figure 2 shows the indoor unit ready for test inside the laboratory enclosure.

## OUTDOOR UNIT

The outdoor unit consisted essentially of a finned coil, a blower, a hermetically-sealed motor-compressor, an expansion valve, a check valve, a four-way valve, a condensate drain, and 24-volt controls for operation and defrost. Material and dimensional data on the components of the outdoor unit are contained in the Appendix at the end of the report.

Figure 3 shows the outdoor unit with test equipment. Note the five-in-one thermocouple system and the thermostat used for controlling outdoor conditions during the test.

The heat pump system arrived from the manufacturer with a complete R-22 charge, contained principally in the outdoor unit. The amount of charge was selected to be adequate for installations employing moderate length liquid and vapor lines. The indoor unit held R-22 under pressure within its coils and refrigerant lines. Gas was released from the indoor unit when the lines between outdoor and indoor units were connected, thus indicating that the indoor lines were probably without leaks.

The controls on the outdoor unit consisted of a defrost control system employing a pressure-sensing device and a defrost termination switch, and a combination high and low pressure switch.

FIGURE 2 INDOOR UNIT IN TEST ENCLOSURE

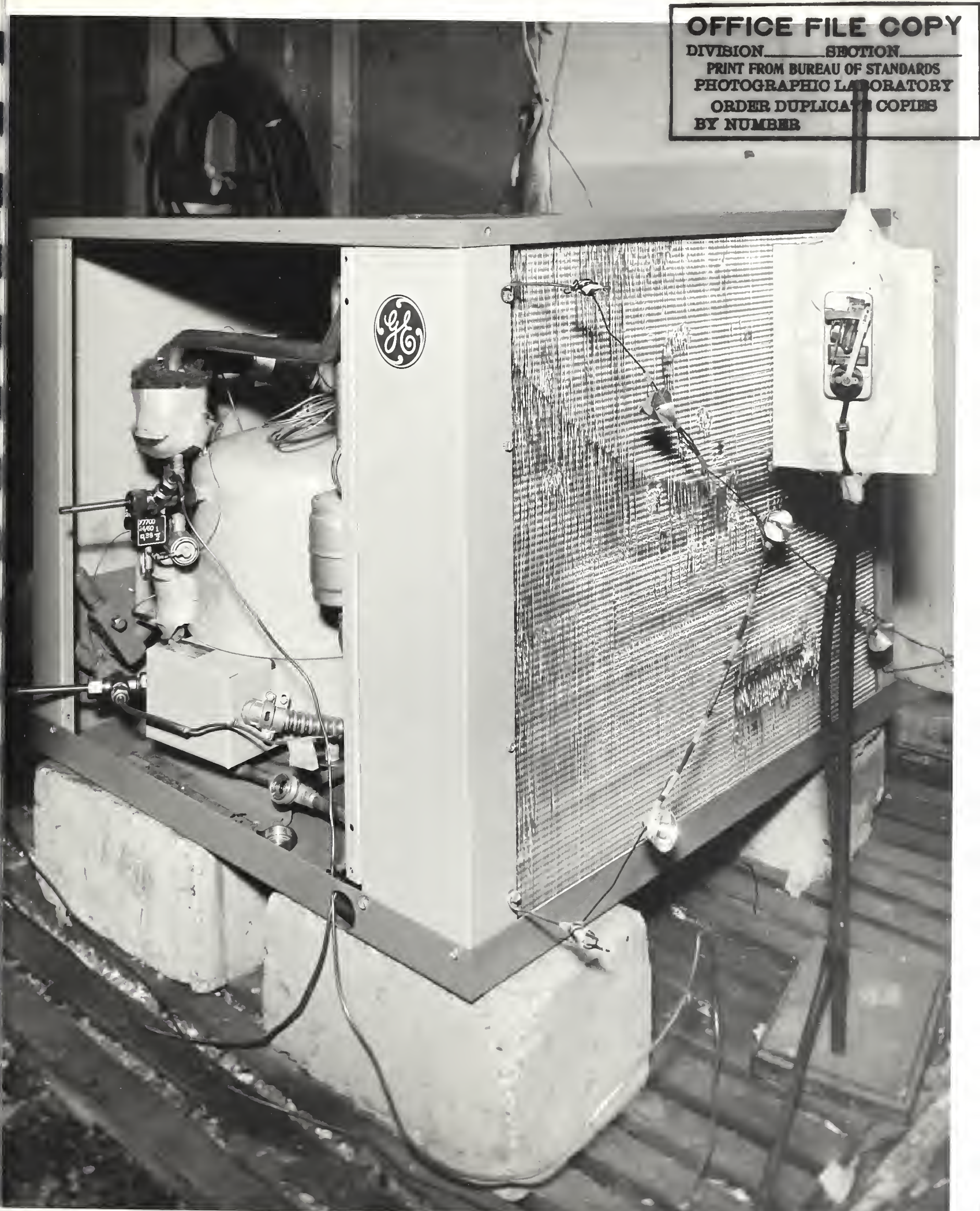


FIGURE 3 OUTDOOR UNIT WITH TEST EQUIPMENT

Defrosting was initiated by a pressure-sensing device actuating the solenoid of the four-way valve to place the unit on cooling operation. Under these conditions the outdoor coil became a condenser and the frost was melted by the heat rejection in the condenser. The outdoor fan was stopped during the defrosting period. The pressure-sensing device employed a diaphragm, which was actuated by a threshhold difference between atmospheric pressure and the pressure at the inlet to the outdoor fan. This pressure difference gradually increased as frost accumulated on the outdoor coil.

The defrost termination switch ended the defrost period when a sufficiently high temperature was reached in the outdoor coil to assure that no frost remained. When this switch opened, the four-way valve was switched from cooling to heating operation and the outdoor fan was energized again. Defrosting could not be initiated by the pressure-sensing device unless the defrost termination switch was closed, but this was its normal position during winter operation. During spring or summer operation the defrost termination switch was always open.

During the defrosting period, the suction pressure sometimes fell below the setting of the low-pressure cut-off switch. Stopping of the compressor was prevented, however, by means of an electrical shunt around the low-pressure switch that was closed when the defrost relay operated.

The high pressure switch stopped the unit when the discharge pressure was too high and the low-pressure switch stopped the unit when the suction pressure was too low. The high pressure switch was of the manual reset type and the low pressure switch of the automatic reset type.

## 3. METHODS OF TESTING

Except for minor deviations, the heat pump was tested under the conditions described in ASRE Testing and Rating Standard No. 16-56. Figure 4 shows the enclosure housing the indoor unit and the 33-in. square test duct attached to the outlet side of the unit. This duct housed the nozzle used for measuring the air circulation rate and the instruments for measuring

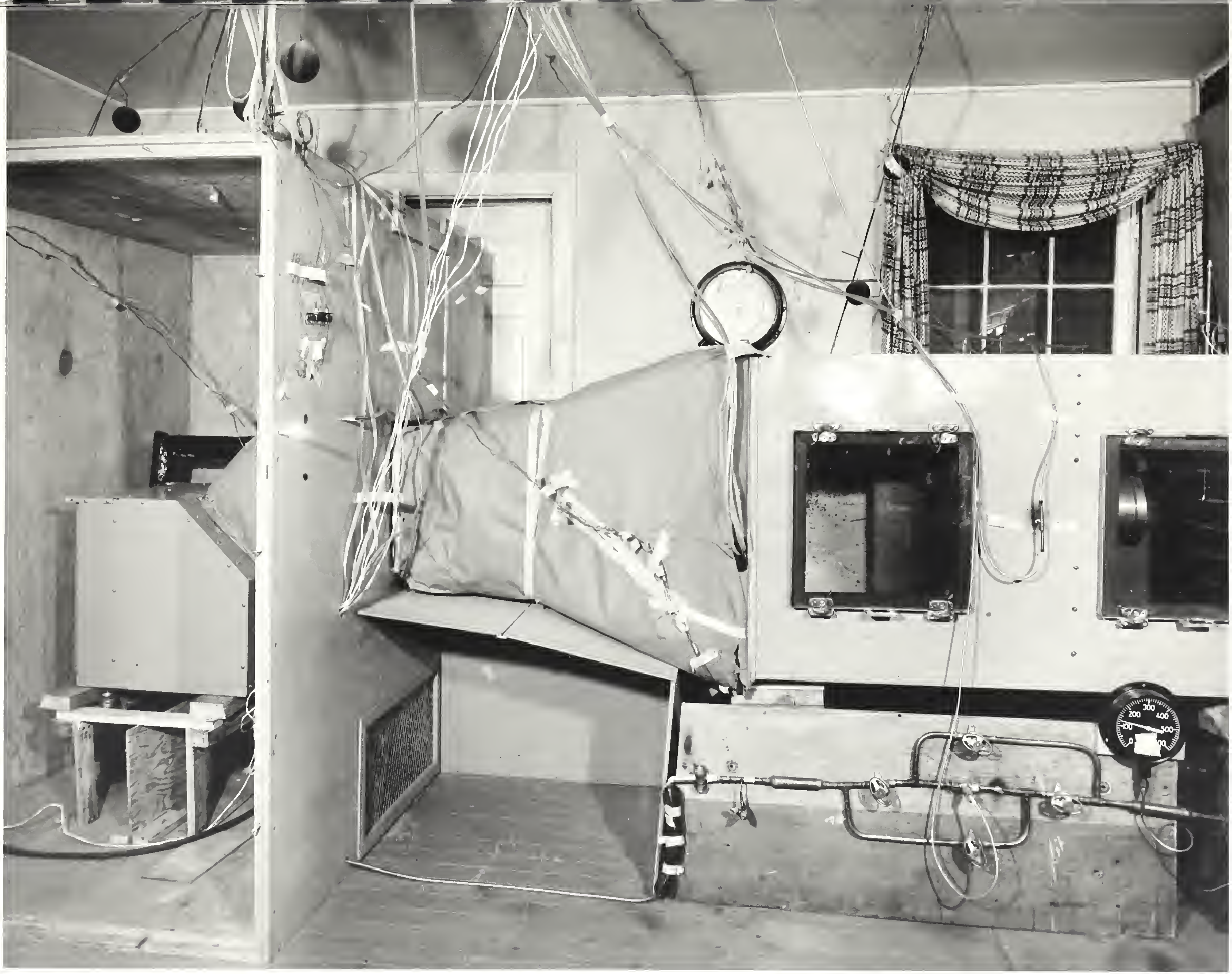

FIGURE 4 TEST ENCLOSURE; DUCT SYSTEM AND MANIFOLD

temperature and humidity of the outlet air. Because the nozzle, mixing baffles, and mixing screen introduced considerable resistance in the outlet duct, an auxiliary blower powered by a one HP motor was provided at the downstream end of the 33-in. duct. Required adjustments of external static resistance on the unit under test were made by a wooden slide-type damper at the outlet of the auxiliary blower. The air delivery rate of the indoor blower depended only on the adjustment of this damper, since the pulley on the blower was not adjustable. The auxiliary blower, return air heaters, and humidifier are shown in Figure 5.

ASRE Standard 16-56 requires that two independent measuring methods be used during the test to provide greater reliability in the results. One method, known as the psychrometric method, involved measuring the mass flow of air through the indoor unit and the change in enthalpy of the air between inlet and outlet of the unit. The other method, referred to as the flowmeter method, involved determination of the rate of flow of refrigerant through the indoor coil and the change in enthalpy of the refrigerant between inlet and outlet of the indoor coil. A correction to the total enthalpy change of the refrigerant was necessary, either by adding or subtracting the heat equivalent of the electrical energy supplied to the indoor blower motor depending on whether the heating or cooling cycle was in use, before comparing it with the result of the psychrometric method. Acceptable precision required that the values obtained by the two methods should not differ by more than six percent.

Mass flow rate of air in the psychrometric method was determined by measuring humidity and temperature conditions of the air entering the long-radius nozzle and the static pressure drop across the nozzle. Enthalpy change of the air was determined by measuring temperature, humidity, and barometric pressure of the air entering the indoor unit, and in the duct immediately after it left the unit.

Flow rate of refrigerant was measured by means of a flowmeter in the liquid line of the system - a Potter Electronic type with an impeller which generated an electrical pulse on

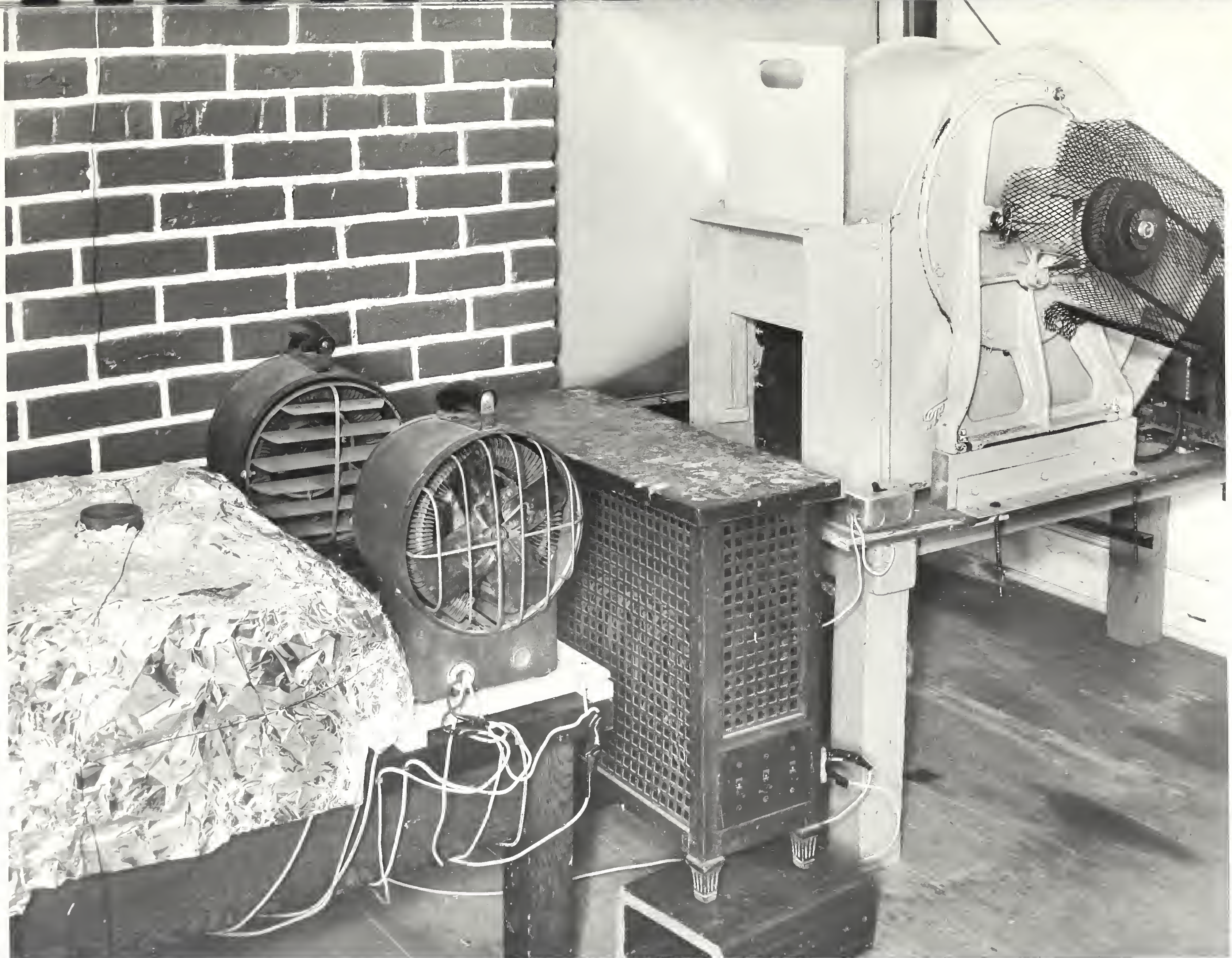

FIGURE 5 AUXILIARY BLOWER

each revolution. A Potter Counter coupled to the flowmeter served to translate the pulses into a volume flow rate. By measuring the temperature of the liquid in the line, the volume flow rate was converted to mass flow rate. Enthalpy change was determined by temperature and pressure measurements at the inlet and outlet of the indoor coil. For accurate measurement of capacity by the refrigerant flow method it was necessary that there be no gas bubbles in the liquid refrigerant as it passed through the meter, and that the liquid refrigerant all be evaporated in the coil.

It was possible to maintain "state" conditions for both cooling and heating with the use of a test structure having two controlled temperatures.

During the tests, the energies consumed by the indoor blower, outdoor fan and compressor were read from separate watthour meters. Simultaneous readings were also made of currents and voltages. The various meters, together with the other instruments for measuring temperature and humidity, are shown in Figure 6.

The same amount of refrigerant charge was used for the cooling tests as for the heating tests. By agreement with the General Electric Co. representative, a run on the cooling cycle at an outdoor temperature of 95°F DB and indoor conditions of 80°F DB and 67°F WB was made at the beginning of the test program with a trial charge. An amount of refrigerant somewhat greater than the factory charge was necessary because of the volume of the gage lines and other lines not found in home installations. After adjusting the charge to obtain the correct pressures and temperatures, operation was switched to heating at 20°F outdoor temperature. Since pressures and temperatures appeared normal under these conditions, the charge was left unchanged for all tests under both heating and cooling conditions. It is of interest to note that specifications at the General Electric plant call for storage of about 8 lbs of refrigerant in the outdoor unit; whereas on completion of the tests, measurements showed that the test charge was very close to 9 lbs. The indications were that no refrigerant leakage occurred during the tests.

Before each test run, steady-state conditions were held for a minimum of one hour. During all runs, readings were taken every ten minutes. In most cases the data for an hour


FIGURE 6 TEST PANEL

representing the steadiest conditions were used for evaluating performance.

During the heating test at an outdoor temperature of 20°F, the pressure drop across the liquid flowmeter was excessive and the flow rate varied in a cyclic manner. For these reasons, the flowmeter data were not used in evaluating this test.

The special test with the coil of the outdoor unit operating under frosting conditions was performed at 35°F with a wind-blown mist directed toward the coil face. Before starting the test, the controls of the unit were arranged so the heat pump would defrost automatically in the normal sequence determined by its defrost controls.

During the morning of the test, fine spray was blown towards the outdoor coil and the rate was adjusted until the defrost cycle occurred once in about 35 to 40 min. During the test, readings were made every ten minutes, as was done for all other tests. When defrost cycles occurred during the periods between readings, the most pertinent pressures, temperatures, and electrical values were read about 2 1/2 minutes after defrost initiation, and when the gages appeared to have become steady under cooling cycle operation. Each defrost cycle lasted from 3 to 4 1/2 minutes. The entire test lasted for 3 hours and all data were used in the calculations.

As a first step in the calculations, capacity was determined in Btu/hr as if no defrost cycles had occurred. As would be expected, calculations showed that capacity decreased as frosting increased during each period between defrosts. As a second step, the heating effect that was lost during the defrosting periods was calculated and subtracted from the values first obtained. Certain approximations were necessary in calculation of this last step because of the difficulty in taking accurate readings during the periods of rapidly changing conditions.

Because of these large and abrupt changes in the refrigerant flow in the system, it was impossible to use the flowmeter during this test.

## 4. TEST RESULTS

A. Table 1 summarizes the results obtained on cooling capacity, heating capacity, and coefficient of performance for the various test conditions agreed upon. These data are plotted separately for the cooling tests and heating tests in Fig. 7 and 8, respectively. These figures show that both the coefficient of performance and the capacity of the heat pump was very nearly linear with respect to outdoor temperature when the indoor conditions were held constant.

Fig. 7 shows that the cooling capacity of the test specimen was reduced an average of 2350 Btu/hr by lowering the indoor dry bulb temperature from 80°F to 75°F and keeping the relative humidity constant. This difference was constant for the range of outdoor temperature from 85°F to 105°F. The change in indoor dry bulb temperature also changed the coefficient of performance by a constant amount throughout this same range of outdoor temperature.

The data in Table 1 show that the static pressure difference between the outlet of the indoor unit and the unit inlet averaged about 0.18 in. W.G. during the heating tests, which were performed first. This was the static pressure created in the system during the heating tests without readjustment of dampers, after initially adjusting the static pressure to 0.15 in. W.G. during cooling conditions.

It was noted as the cooling tests progressed that the static pressure at the unit outlet gradually decreased to values as low as 0.05 and 0.06 in. W.G. This effect was caused by dust deposits on the air filter located in the unit inlet. Changing the filter restored the outlet static pressure to 0.15 in. W.G. A comparison of the three cooling tests in Table 1 at an outdoor temperature of 95°F indicates that static pressure variations in the range from 0.05 to 0.30 in. W.G. caused less than 2 percent change in cooling capacity which is probably less than the precision of this type of test. Air flow rate, however, was reduced by nearly 10% as static pressure changed from 0.15 in. W.G. to 0.30 in. W.G. The air filter was clean for both of these tests.

The variations in static pressure at the unit outlet cannot be correlated satisfactorily with the variations in air delivery because two blowers were connected in series in the test apparatus for these tests.

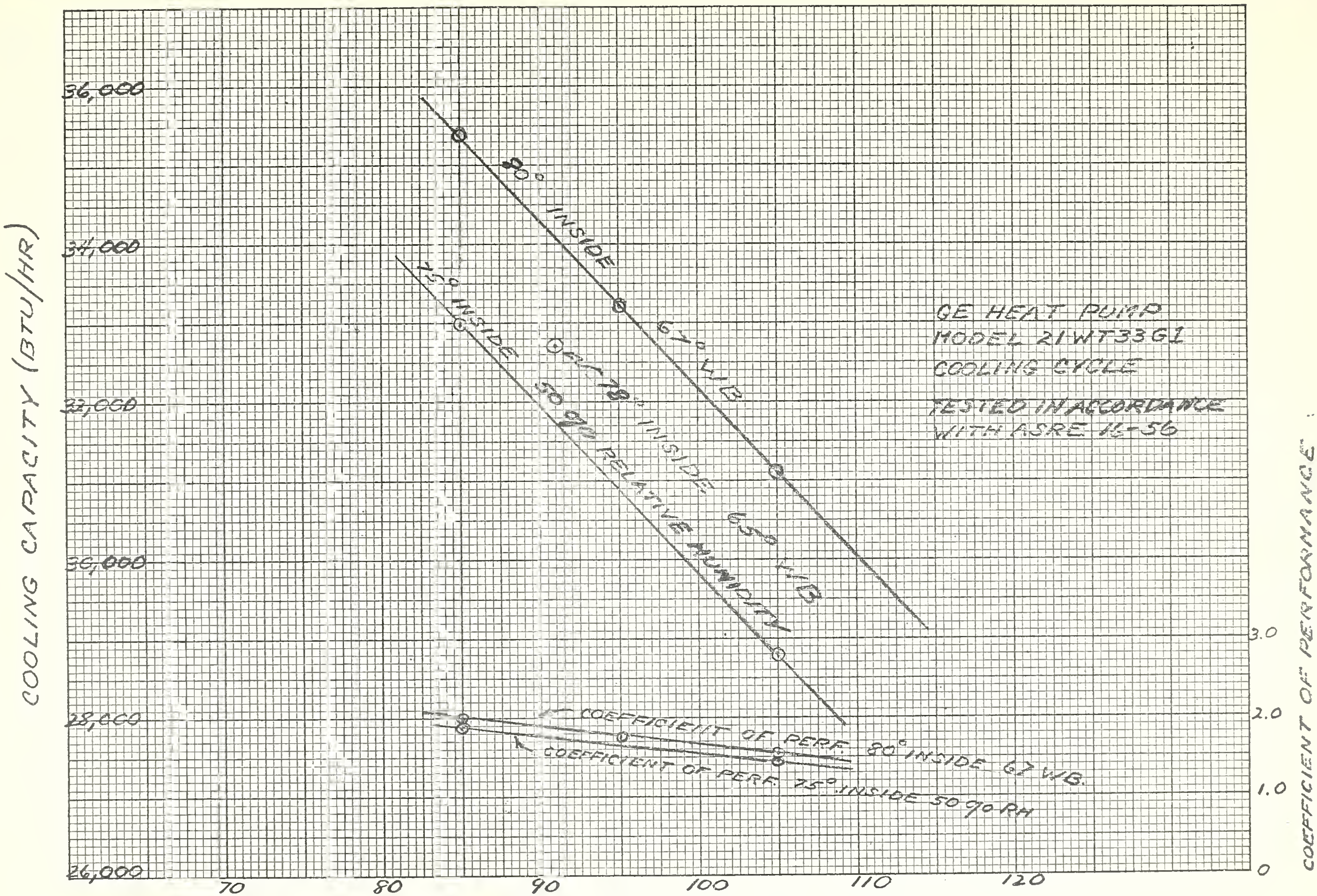
GE HEAT PUMP
MODEL 21WT33G1
COOLING CYCLE
TESTED IN ACCORDANCE
WITH ASRE 16-56
80° INSIDE 67° WB
78° INSIDE 65° WB
75° INSIDE 50% RELATIVE HUMIDITY
COEFFICIENT OF PERF. 80° INSIDE 67 WB.
COEFFICIENT OF PERF. 75° INSIDE 50% RH
COOLING CAPACITY (BTU/HR)
COEFFICIENT OF PERFORMANCE
OUTDOOR TEMPERATURE (°F)

FIG. 7

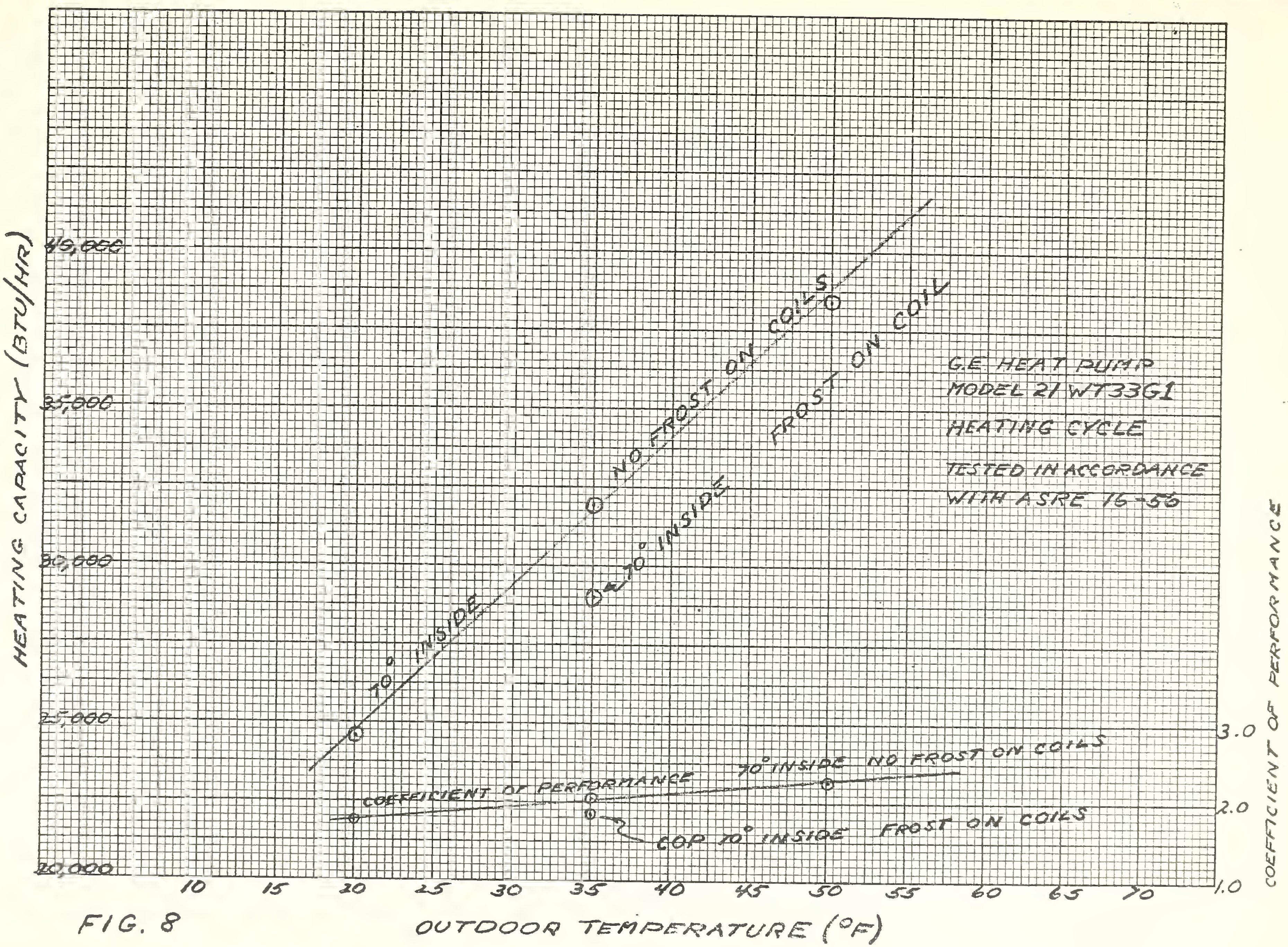
G.E. HEAT PUMP
MODEL 21 WT33G1
HEATING CYCLE
TESTED IN ACCORDANCE
WITH ASRE 16-56
NO FROST ON COILS
FROST ON COIL
70° INSIDE
70° INSIDE
COEFFICIENT OF PERFORMANCE
70° INSIDE NO FROST ON COILS
COP 70° INSIDE FROST ON COILS
HEATING CAPACITY (BTU/HR)
40,000
35,000
30,000
25,000
20,000
10
15
20
25
30
35
40
45
50
55
60
65
70
OUTDOOR TEMPERATURE (°F)
COEFFICIENT OF PERFORMANCE
3.0
2.0
1.0

FIG. 8

Table 1

RESULTS OF TESTS

COOLING CONDITIONS

| Test Conditions: Inside DB (°F) | Inside WB or Humidity (°F or %) | Outdoors DB (°F) | Stat. Res. at Outlet of Indoor Unit (in. W.G.) | Air Delivered by Blower (cfm) | Psychrometric Capacity (Btu/hr) | Flowmeter Capacity (Btu/hr) | Allowance for Deviation of Bar. Press. (Btu/hr) | Corrected Average Value (Btu/hr) | C.O.P. |
|---|---|---|---|---|---|---|---|---|---|
| 80 | 67 | 95 | 0.30 | 1110 | 32,570 | 32,870 | - | 32,700 | 1.73 |
| 80 | 67 | 95 | .15 | 1215 | 33,520 | 32,970 | - | 33,200 | 1.73 |
| 80 | 67 | 95 | .05 | 1140 | 33,690 | 32,350 | 50 | 33,100 | 1.75 |
| 78 | 65 | 91 | .12 | 1210 | 32,860 | 32,400 | 80 | 32,700 | 1.77 |
| 80 | 67 | 85 | .06 | 1145 | 35,850 | 34,600 | 190 | 35,400 | 1.97 |
| 80 | 67 | 105 | .02 | 1140 | 31,430 | 30,610 | 50 | 31,100 | 1.55 |
| 75 | 50% | 85 | .15 | 1215 | 34,100 | 31,990 | - | 33,000 | 1.88 |
| 75 | 50% | 105 | .15 | 1220 | 29,200 | 28,490 | - | 28,800 | 1.47 |

HEATING CONDITIONS

| Inside DB (°F) | Inside WB or Humidity | Outdoors DB (°F) | Stat. Res. (in. W.G.) | Air (cfm) | Psychrometric Capacity (Btu/hr) | Flowmeter Capacity (Btu/hr) | Allowance (Btu/hr) | Corrected Average Value (Btu/hr) | C.O.P. |
|---|---|---|---|---|---|---|---|---|---|
| 70 | | 20 (No frost) | .19 | 1195 | 24,440 | - | 110 | 24,600 | 1.74 |
| 70 | | 35 (No frost) | .18 | 1195 | 32,740 | 30,580 | 190 | 31,900 | 2.03 |
| 70 | | 50 (No frost) | .16 | 1190 | 38,730 | 37,180 | 400 | 38,400 | 2.23 |
| 70 | | 35 (Frost)* | .18 | 1230 | - | - | 400 | 29,000 | 1.87 |

* See discussion following on this test

B. Cooling Test Under Standard ASRE Conditions

Details of a typical cooling test with the outdoor temperature at 95°F, the indoor temperature at 80°F DB, and with 67°F WB are given below. Static resistance at the outlet of the indoor blower was 0.15 in. W.G. for this test.

Summary of Cooling Capacity Values (Btu/hr)

| | | Test Value | Rounded Value |
|---|---|---|---|
| By psychrometric method | | 33,520 | |
| By flowmeter method | | 32,970 | |
| | Average | 33,245 | |
| Allowance for deviation of barometric pressure from normal | | 0.0 | |
| | Total | 33,245 | 33,200 |

Psychrometric Method

Air Temperatures (°F)

| | |
|---|---|
| At inlet to enclosure around indoor unit | 79.9 |
| At outlet of indoor unit in duct | 60.5 |
| Temperature difference across indoor coil | 19.4 |
| At inlet to outdoor unit | 95.0 |

Wet Bulb Depressions

| | |
|---|---|
| At inlet to enclosure around indoor unit | 13.0 |
| At outlet of indoor unit in duct | 2.5 |

Static pressure across nozzle (in. W.G.) 1.35

| | |
|---|---|
| Volume air flow at nozzle (cfm) | 1215 |
| Mass air flow at nozzle (lb dry air/hr) | 5480 |
| Barometric pressure (in. Hg) | 29.94 |
| Area of nozzle (sq ft) | 0.268 |
| Nozzle coefficient | 0.981 |
| Static resistance external to unit (in. W.G.) | 0.15 |

Flowmeter Method

Refrigerant Temperatures (°F)

| | |
|---|---|
| In vapor line leaving coil of indoor unit | 49.7 |
| In liquid line entering coil of indoor unit | 111.4 |
| Superheat at indoor coil outlet | 5.0 |
| Subcooling at indoor coil inlet* | 9.2 |
| In discharge line of compressor | 233.0 |
| In suction line of compressor | 63.4 |

* Subcooling determined using pressure at point of measurement

Refrigerant Pressures (psig)**

| | |
|---|---|
| Compressor discharge | 290 |
| In liquid line preceding flowmeter | 278.5 |
| In liquid line entering coil of indoor unit | 271 |
| Pressure drop across flowmeter | 7.5 |
| In vapor line leaving coil of indoor unit | 76 |
| In suction line of compressor | 70.5 |

** Pressure referenced to compressor level

| | |
|---|---|
| Potter meter count for 1 minute | 32.7*** |

Motor power consumption (Watts)

| | |
|---|---|
| Indoor blower | 460 |
| Outdoor fan | 540 |
| Compressor | 4620 |
| Total | 5620 |

*** $\text{Refrigerant flow, gal./min} = \dfrac{\text{count for one minute x 100}}{3365.5}$

| | |
|---|---|
| Coefficient of performance | 1.73 |
| **Motor voltages (Volts)** | |
| Indoor blower | 115.5 |
| Outdoor fan | 230.0 |
| Compressor | 230.0 |
| **Motor current (Amperes)** | |
| Indoor blower | 4.9 |
| Outdoor fan | 2.6 |
| Compressor | 20.5 |

## C. Heating Test at 20°F Outdoor Temperature

Details of the heating test with the outdoor temperature at 20°F and the indoor temperature at 70°F are given below:

Summary of Heating Capacity Values (Btu/hr)

| | Test Value | Rounded Value |
|---|---|---|
| By psychrometric method | 24,440 | |
| Allowance for deviation of barometric pressure from normal | 110 | |
| Total | 24,550 | 24,600 |

### Psychrometric Method

| Air Temperatures (°F) | |
|---|---|
| At inlet to indoor unit | 70.0 |
| At outlet of indoor unit in duct | 89.8 |
| Temperature difference across indoor coil | 19.8 |
| At inlet to outdoor coil | 20.6 |

| | |
|---|---|
| Relative humidity of indoor air in duct (%) | 12.7 |
| Static pressure across nozzle (in. W.G.) | 1.23 |
| Volume air flow at nozzle (cfm) | 1195 |
| Mass air flow at nozzle (lb dry air/hr) | 5095 |
| Barometric pressure (in. Hg) | 29.69 |
| Area of nozzle (sq ft) | .268 |
| Nozzle coefficient | .981 |
| Static pressure at indoor blower outlet (in. W.G.) | .19 |

Refrigerant Pressures (psig)*

| | |
|---|---|
| Compressor discharge | 229.5 |
| In vapor line entering coil of indoor unit | 227.0 |
| In liquid line leaving coil of indoor unit | 225.5 |
| In liquid line after flowmeter | 217.0 |
| Pressure drop across flowmeter | 8.5 |
| Suction pressure at compressor | 27.0 |

* Referenced to compressor level

Other Temperatures

| | |
|---|---|
| Compressor discharge | 217.8 |
| Near 4-way valve between valve and indoor unit | 195.3 |
| At inlet to coil of indoor unit | 191.4 |
| At outlet to coil of indoor unit | 76.5 |
| Suction line at compressor | 18.9 |
| Superheating at compressor | 107.0** |
| Superheating at inlet to coil of indoor unit | 82.6** |
| Subcooling at outlet to indoor unit | 32.0** |
| Superheating at suction line of compressor | 15.5** |

** Subcooling or superheating determined using pressure at point of measurement

Motor power consumption (Watts)

| | |
|---|---|
| Indoor blower | 411.5 |
| Outdoor fan | 650.5 |
| Compressor | 3072.5 |
| Total | 4134.5 |

| | |
|---|---|
| Coefficient of performance | 1.74 |
| **Motor voltages** | |
| Indoor blower | 115.0 |
| Outdoor fan | 230.0 |
| Compressor | 230.0 |
| **Motor current (Amperes)** | |
| Indoor blower | 4.5 |
| Outdoor fan | 3.1 |
| Compressor | 14.3 |

## D. Heating Test with Frosted Coil

A summary of the capacity values for the heating test with frosted outdoor coil is shown below. The outdoor temperature was 35°F.

Heating Capacity Values (Btu/hr)

| | Test Value | Rounded Value |
|---|---|---|
| By psychrometric method | 31,960 | |
| By flowmeter method (estimated*) | 29,820 | |
| Average of two methods | 30,890 | |
| Loss in capacity during defrost cycles | 2,310 | |
| Net value | 28,580 | |
| Allowance for deviation of barometric pressure from normal | 400 | |
| | 28,980 | 29,000 |

* Estimate based on ratio or psychrometric value of flowmeter values for heating test at 35°F outdoors without frost.

## E. Motor Currents vs. Nominal Ratings

The current used during the tests by the motors on the indoor blower and outdoor fan was within that allowed by the National Electric Manufacturers Association Standards, or 1.35 service factor times the nominal rating. Nominal ratings, allowable maximum current, and the maximum readings observed during the tests are summarized below:

| | Nominal Ratings (amperes) | Allowable Maximum Current (amperes) | Maximum Current Reading (amperes) |
|---|---|---|---|
| Indoor blower | 4.30 | 5.80 | 4.95 |
| Outdoor fan | 2.35 | 3.17 | 3.00 |

Values as low as 2.50 amperes were obtained for the outdoor fan on the cooling tests and 4.43 amperes for the indoor blower on the heating tests.

Information on the nominal current rating of the compressor motor was not readily available.

## F. Temperature drop across 4-way valve, heating test

During heating tests on other heat pumps at 20°F outdoor temperature, the temperature drop between the compressor and inlet to the indoor coil was greater than 30°F. In all cases the vapor line was well insulated where it was surrounded by the cold outdoor temperature. This decrease in temperature seemed rather large but there was insufficient instrumentation used during testing to make a complete analysis of the causes.

During the test on the Model 21 WT33G1 General Electric Company heat pump extra thermocouples were placed in the outdoor unit, one of which was positioned on the vapor line between the 4-way valve and the indoor unit. In this way it was possible to isolate data for the temperature drop due to heat exchange in the 4-way valve.

Inspection of the listing of refrigerant temperatures for the 20°F heating test, Part C of the Test Results, will show that the temperature decreased from the compressor discharge to the inlet of the coil in the indoor unit about 26°F, and that 22°F of this decrease occurred across the 4-way valve. A rather high value like this would be expected considering the large difference in temperature of 199°F between the discharge gas and the suction gas entering the 4-way valve. Temperatures measured during the 35°F and 50°F heating tests showed temperature drops in each case of about 20°F between compressor discharge and indoor unit, with about 10°F drop across the 4-way valve.

G. Calculation of oil in content in refrigerant

To determine the amount of oil flowing through the lines with the refrigerant and the effect of this oil on the flowmeter registration, the refrigerant was sampled under both cooling and heating conditions. The refrigerant, taken from the line while the heat pump was operating, was discharged into special flasks precooled by dry ice, and then allowed to evaporate slowly as the ice melted, leaving a residue of oil. The ratio of oil to refrigerant was measured volumetrically. This method was checked by a gravimetric method in which the refrigerant was withdrawn from the heat pump liquid line into an evacuated copper vessel at room temperature, and the residue of oil weighed after the refrigerant had slowly evaporated for comparison with the weight of refrigerant and oil. The ratio of oil to refrigerant was about 0.01 by weight for both cooling and heating conditions, and agreed reasonably well with the volumetric determinations.

# APPENDIX

## A. Material and Dimensional Data on Components of Indoor Unit

### Coil

Three rows of 3/8 in. OD copper tubing, 20 tubes each row 1 in. apart, center to center. 14 aluminum fins per inch of tube length. Dimension of coil assembly: 20 in. high, 25 in. wide, 4 1/2 in. deep.

### Blower

Centrifugal; direct driven; wheel, 9 1/2 in. wide, 10 in. diameter; scroll, 12 in. wide, 14 1/2 in. diameter.

### Blower Motor

General Electric AC 1/6 HP, 1075 rpm. Model 5KCP3966609T. Thermal protection. GE J3308, 50°C rise. cont. air over motor. Ser. VRD-2, 4.3 amps. 115 volts, 60 cycles. Requires oiling.

### Expansion Valve

Alco, non-adjustable, thermostatic type, 3/8 in. OD sweat, 237 HG. Charged thermal bulb. External equalizer, 1/4 in. OD line.

### Check Valve

One-half in. sweat, pressure-activated.

### Air Filter

One glass fiber filter, throw-away type, 20 in. wide, 20 in. high, 1 in. thick.

### Insulation of Cabinet

One in. of glass fiber covered with moisture-resistant paper.

Description of Lines Inside Indoor Unit

Liquid line 3/8 in. OD. Vapor line 5/8 in. OD and 7/8 in. OD. Header line 5/8 in. OD. Four 1/4 in. distributor lines to coil. All lines brazed with "Sil-Fos"-type solder.

Housing Dimension, Indoor Unit

21 in. high, 22 1/2 in. wide, 22 1/2 in. deep, Duct opening, 10 1/2 in. by 11 3/4 in. Wall thickness .048 in.

Nameplate, Indoor Unit

Model 21 WTB32E9. Motor 1/6 HP, 3.6 F.L. amps, 1 phase, 60 cycles, 115 volts. Test pressure 420 psi, Refrigerant-22, Ser. No. 2002900.

B. Material and Dimensional Data on Components of Outdoor Unit

Coil

Three rows of 1/2 in. OD copper tubing, 20 tubes each row, 1 1/4 in. apart, center to center. Twelve aluminum fins per in. of tube length. Dimension of coil assembly: 25 in. high, 28 1/2 in, wide, 3 1/4 in. deep.

Fan

Propeller "pull through" type, direct driven, 20 in. diameter, for 1/2 in. shaft. 5 blades, metal, approximately 40° pitch.

Fan Motor

General Electric 1/3 HP, 1075 rpm. Model 5KCP37MG1351, 230 volts, 2.35 amps, 60 cycles, 1 phase, thermal protection, 50°C rise, cont. air over motor, 1/2 in. shaft, Ser. No. WRD-2. Requires oiling, capacitor start.

Motor-Compressor Unit

General Electric, Refrigerant-22, Model 21CT 4HH41, 230 volts, 1 phase, 60 cycles, Serial No. 132873840, F.L. amps. 21.5, L.R. amps. 98, test pressure 350 psi. Rubber mounted. Hermetic sealed. Includes thermal overload and external locked rotor protector, both automatically reset.

Expansion Valve

Alco, non-adjustable, thermostatic type, 5/8 in. OD sweat, external equalizer, 1/4 in. line, charged thermal bulb.

Check Valve

Pressure-activated, 1/2 in. OD sweat.

Four-Way Valve

Alco, Solenoid-operated on low voltage 24 volts.

Other Components

Drier in liquid line 1/2 in. OD sweat, sight glass, 1/2 in. OD sweat.

Insulation in Housing

One inch of glass fiber, 9 in. by 31 1/2 in. under top cover to cover coil assembly only. No foil.

Description of Lines of Outdoor Unit

Discharge line from compressor to 4-way valve 1/2 in. OD. Suction line from compressor to 4-way valve, 7/8 in. OD. Line from 4-way valve to coil 7/8 in. OD. Vapor line inside of unit 7/8 in. OD. Liquid line inside of unit 1/2 in. OD. Three distributor lines from expansion valve to coil 1/4 in. OD. Header line 7/8 in. OD. All lines brazed with "Sil-Fos"-type of solder.

Housing, Outdoor Unit

25 1/2 in. high, 31 1/2 in. wide, 28 in. deep. Thickness, .048 in.

Nameplate Covering Outdoor Unit

General Electric Weathertron Model 21 WTA40B11, Ser. No. 253321S40, Fan motor 1/3 HP, 2.35 amps, 230 volts, 1 phase, 60 cycles, compressor motor amps. 20.0, 230 volts, 1 phase, 60 cycles, L.R. amps. 96 Ref.-22, 8 lbs, high side test 420 psi, low side test 150 psi. Cat. No. 21D1011387, Ser. No. 353321840.

U. S. DEPARTMENT OF COMMERCE
Lewis L. Strauss, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

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